PROTEIN SPARING EFFECTS OF CARBOHYDRATE IN AFRICAN CATFISH, *Clarias gariepinus*

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ABSTRACT

Feeding trial was conducted to examine the protein sparing effects of carbohydrate in Clarias gariepinus, an attempt to reduce the feed cost. Clarias gariepinus fingerlings mean weights of 8.32 ±0.04g were randomly allotted into a group of 15 fishes per tank in triplicate of 10 treatments. They were fed on nine experimental diets and a commercial catfish reference diet (CRD). The formulated diets have three levels of carbohydrate (5, 10 and 20%) of three carbohydrate sources (cornfibre, cornstarch and glucose) and three levels of crude protein (30%, 25% and 20%). The results of the trial showed significant differences (p<0.05) in all the carbohydrate sources fed to Clarias gariepinus at different levels of carbohydrate/ protein ratios. However, of the three carbohydrate sources, corn starch and glucose spared protein for growth while cornfibre did not.

KEY WORDS: Protein sparing, effects, Carbohydrate sources, *Clarias gariepinus*

INTRODUCTION

Carbohydrates are important non-protein energy sources for fish and should be included in their diets at appropriate levels which maximize the use of dietary protein for growth. The amount of non-protein energy sources that can be incorporated in fish diets is not fully understood and as such no dietary requirement for dietary carbohydrate has been demonstrated in fish; however, certain fish species exhibit reduced growth rates when fed carbohydrate free diets (Wilson, 1994). Carbohydrate utilisation is much more variable and probably is related to natural feeding habits, and incorporation of this nutrient may add beneficial effects to the pelleting quality of the diet and to fish growth (Wilson, 1994; NRC, 1993). Excessive dietary carbohydrate in fish diet may also lead to fat deposition by stimulating the activities of lipogenic enzymes (Likimani and Wilson, 1982). Thus, rainbow trout (Brauge *et al.*, 1994), *Tilapia zillii* (El-sayed and Garling, 1988), and red drum, sciaenops (Serrano *et al.*, 1992; Ellis and Reigh, 1991) have been reported to have poor utilization for carbohydrate than *Oreochromis niloticus* (Shimeno *et al.*, 1993).

Information on nutritional studies in African catfish *Clarias gariepinus* seems limited and have been dealt mainly with dietary protein and energy requirements using semi purified diets (Degani *et al.*, 1989; Uys, 1989; Henken *et al.*, 1986; Machiels and Henken, 1985). Until now, carbohydrate utilization has not been studied, although *Clarias gariepinus* is reported to be omnivorous and might utilize carbohydrate well. The objective of this study is to determine the carbohydrate sparing effects of protein in African catfish *Clarias gariepinus*.

MATERIALS AND METHODS

Experimental System

The study was conducted in a recycling water system of the Department of Water Resources, Aquaculture and Fisheries Technology of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna. Water quality parameters of the set up were monitored. (Temperature: 24.5-25.60; pH: 6.0-7.5; Conductivity (μ/cm) x 10-2: 74.12-103.34; Dissolve oxygen (mg/L:5.50-6.60±3.00; Ammonia nitrogen (mg/L): 0.07 - 0.36±0.05;

Nitrate nitrogen (mg/L): 0.39 - 6.07 ± 250.00; Nitrite nitrogen (mg/L): 0.02- 0.24 ±0.25.

Experimental Diets

The experimental design was complete randomized design (CRD). Nine experimental diets and one commercial reference diet [(CRD)- Coppens Catfish feed from Netherland)] were used for the feeding trial. The experimental diets were formulated using equational method of two unknowns. Nine experimental diets of three levels of protein (30%, 25% and 20% CP) were formulated with three sources of carbohydrate; complex, moderately complex and simple sugar (Cornfibre, Corn starch and Glucose-D) at 5, 10 and 20% inclusion levels. The Table of formulation and its proximate analysis is shown in Table 1.

Experimental Fish

150 fingerlings of African catfish, *Clarias gariepinus* of mean weight 8.32 ±0.04 g were obtained from the hatchery unit of the Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna. The fishes were acclimatized for one week and fed on commercial catfish diet (crude protein 45%). At the commencement of the feeding trial, a group 15 fishes were randomly selected, weighed and assigned to 50 litres cylindrical tank. The treatments were randomly assigned to a triplicate group of the tanks. The duration of the experiment was 8 weeks. Before the commencement of the feeding trial, 7 fishes from the acclimated lots were randomly sacrificed for determination of initial whole body composition. The fishes were bulked weighed fortnightly and at the end of the experiment, all fishes were weighed and counted individually. 5 fishes from each tank were collected for determination of final whole body composition. The fishes were fed twice daily between the hours 10.00 and 16.00 to apparent satiation.

Experimental Analyses and Growth Parameters

Proximate analysis for moisture, crude protein, crude lipid and ash of carcass, feed ingredients and experimental diets were determined according to the methods of AOAC (2000). Final values for each group represent the arithmetic mean of the triplicates. Feed intake was monitored to measure average feed intake and their effects on growth. The growth and nutrient utilization parameters measured include weight gain, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), Apparent Net Protein Utilization (ANPU). The growth parameters were computed as stated below;

Mean weight gain = Mean final weigh - mean initial weight

Specific Growth Rate (SGR) =

$$\frac{(Log_e W_2 - Log_e W_1) \times 100}{T_2 - T_1}$$

Where, W_2 and W_1 - final and initial weight, T_2 and T_1 - final and initial time

Feed conversion ratio - Feed fed on dry matter/fish live weight gain

Protein efficiency ratio (PER) =Mean weight gain per protein fed

Protein intake (g) = Feed intake x crude protein of feed.

Apparent net protein utilization (ANPU %) = (P2 - P1) / Total protein consumed (g) x 100

Where, P1 is the protein in fish carcass (g) at the beginning of the study and P2 is the protein in fish carcass (g) at the end of the study.

Statistical Analysis

The experimental design was factorial and the data was subjected to one way analysis of variance to test their significant levels at 5% probability. The mean were separated using Turkey's method. The regression coefficients were analyzed using Minitab Release 14 while the graphs were drawn using the Microsoft excel windows 2007.

RESULTS

Growth, Survival and Feed Performance

Tables 1 and 2 show feed composition/ proximate analysis and results of growth parameters for various carbohydrate sources fed *Clarias gariepinus*. The growth performance of *Clarias gariepinus* fed cornfibre at three levels of carbohydrate and protein (C/P) ratios indicated no significant differences ($p<0.05$) between treatment 10:25 and 20:20 C/P ratios both of were significantly lower ($p<0.05$) than 5: 30 in mean weight gain (MWG) and specific growth rate (SGR). There were no significant differences ($p>0.05$) in the feed conversion ratios (FCR) for all the treatments. There were significant differences ($p<0.05$) in the protein efficiency ratios (PER) of treatments 15:25 and 20:20 C/P ratios, which were significantly higher ($p<0.05$) than 5:30 C/P ratio. There were significant differences ($p<0.05$) in the apparent net protein utilization (ANPU) for all the treatments, which was highest for diet 20:20 C/P ratio. The survival percentages also indicated significant differences ($p<0.05$) between diets 15:25 and 20:20 both of which were significantly higher ($p<0.05$) than 5:30 C/P ratio.

The cornstarch based diets did not exhibit significant differences ($p>0.05$) for all the treatments, however, diet 20:20 C/P ratio gave the lowest mean weight gain (MWG). There were significant differences ($p<0.05$) in the SGR for all the treatments, which was highest in 10: 25 C/P ratio. The FCR values also indicated significant differences ($p<0.05$) for all the treatment but diet 10:25 gave the lowest FCR value. There were significant differences ($p<0.05$) in the PER values for all the treatments which was highest for 20:20 C/P ratio. However, the ANPU values also showed significant differences ($p<0.05$) for all the treatments but diet containing 10:25 C/P ratio gave the highest value.

The cornstarch based diets exhibited insignificant differences ($p>0.05$) in the MWG for treatments 5:35 and 10:25 C/P ratios both of which were significantly higher ($p<0.05$) than 20:20 C/P ratio. There were significant differences ($p<0.05$) for the treatments in the SGR values which was highest with 10: 25 C/P ratio. The FCR values also were significant ($p<0.05$) for all the treatments, which was lowest for 10:25 C/P ratio. There were significant differences ($p<0.05$) in the PER and ANPU values for all the treatments, which were highest for 20:20 and 10:25 C/P ratios respectively. The survival percentage was significant ($p<0.05$) for all the treatments but was lowest for 15:25 C/P ratio.

The glucose based diets indicated insignificant differences ($p>0.05$) for all the treatments in the MWG and SGR values. There were significant differences ($p<0.05$) in the FCR for all the treatments but was lowest for 20:20 C/P ratio. The PER values indicated no significant differences ($p>0.05$) between diets 5:30 and 10: 25 both of which were significantly lower ($p<0.05$) than 20:20 C/P ratio. The ANPU values were significant for all the treatments but highest for 20:20. The survival percentages indicated no significant differences ($p>0.05$) between diets 5:25 and 20:20 but were significantly high ($p<0.05$) for 10:25.

Nutrient Utilization

Table 3 showed the results of the nutrient utilization. There were no significant differences ($p>0.05$) between diets 15:25 and 20:20 in the body protein and significantly higher ($p<0.05$) than 5:30. The body fat showed significant difference ($p<0.05$) for all the treatments, which was highest for 5:30 C/P ratio. The body ash indicated significant differences ($p<0.05$) for all the treatments but was lowest for 20:20 C/P ratio. There were significant differences ($p<0.05$) in the moisture content but lowest for 10:30 C/P ratio.

The cornstarch based diets exhibited significant differences ($p<0.05$) in the body protein for all the treatments, which was highest for 15:25 C/P ratio. Similarly, the body fat indicated significant differences ($p<0.05$) for all treatments but was lowest for 20:20 C/P ratio. The body ash also expressed significant differences ($p<0.05$) for all the treatments, however, diet 10:25 gave the lowest body ash. There was also significant differences ($p<0.05$) in the body moisture contents, which was lowest for diet 20:20 C/P ratio. The glucose based diets indicated significant differences ($p<0.05$) in the body protein for all the treatments but was highest for 20:20. The body fat also showed significant differences ($p<0.05$) for all treatments but was lowest for 5: 30 C/P ratio. Similarly, there were significant differences ($p<0.05$) in the body ash and body moisture, which are lowest for 10:25 and 20:20 C/P ratios respectively.

However, the growth responses for cornfibre and glucose shown in figures 1 and 3 indicated a bundle growth curve while, the corn starch appeared to have a better protein sparing toward the end of the feeding trial at 10:25 C/P ratio (Figure 2). The regression co-efficient showed positive relationship between weight gain and the glucose levels ($x = 0.154 + 0.0052y$; $r^2=0.40$; $p<0.05$) (Figure 4a) and negative relationship with protein levels ($x = 0.443-0.088y$; $r^2=0.54$, $p<0.05$) (Figure 4b). The cornstarch showed a negative relationship in its weight gain and the inclusion levels of corn starch ($x = 0.800 - 0.0178y$; $r^2= 0.26$, $p<0.05$) (Figure 5a) and a positive relationship with protein levels ($x = 0.052 + 0.0216y$; $r^2= 0.16$, $p<0.05$) (Figure 5b) while the cornfibre based diets indicated a negative relationship between the weight gain and the cornfibre levels ($x=1.54-0.088y$; $r^2 = 0.66$, $p<0.05$) (Figure 6a) and positive relationship with protein levels ($2.37 + 0.124y$; $r^2= 0.82$, $p<0.05$) (Figure 6b).

DISCUSSION

The results on growth performance observed indicated protein sparing effects of various carbohydrate sources fed *Clarias gariepinus*. However, the protein sparing was influenced by both complexity and inclusion levels (Rawles and Garlin III, 1998). The cornfibre based diet least spared protein as observed from the growth response. The cornfibre based diets gave the best growth at the highest inclusion level of crude protein (40 %) and at lowest levels of fibre. This showed that *Clarias gariepinus* cannot utilize fibre at high inclusion level. Moreover, the cornsatarch spared protein at 10 % inclusion level thereby lowering the crude protein to 25%. Moreover, the growth response (Figure 1) indicated a better protein sparing towards the end of the feeding trial, which presumes possibility of high protein sparing beyond 8 weeks. The glucose gave the best protein sparing at 20% inclusion level in view of the bundle effects of the growth response (Figure 2) which was an expression of protein sparing in view of the fact that, inclusion of glucose at highest level gave equal performance as other levels without negative impact on the growth. The utilization of glucose by *Clarias gariepinus* in this study was contrary to the report of Machiels and VanDam (1987) who reported that *Clarias gariepinus* has low glucose utilization. The observed protein sparing effects of carbohydrate of less complex nature by *Clarias gariepinus* is in agreement with the report of Degani and Revach (1991).

CONCLUSION

The results obtained indicated protein sparing by moderately complex carbohydrate and simple sugar. This has further established the ability of *Clarias gariepinus* to utilize carbohydrate in its diets sparing expensive protein for growth.

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Table 1: Formulation and composition of the experimental diets and proximate analysis

Feedstuffs	Corn fibre (5:30)	Corn starch (5:30)	Glucose (5:30)	Corn fibre (10:25)	Corn starch (10:25)	Glucose (10:25)	Corn fibre (20:20)	Corn starch (20:20)	Glucose (20:20)	CRD
Fishmeal	27.92	33.31	36.39	20.97	26.93	30.33	14.03	20.70	24.26	
Corn fibre	67.09	0.00	0.00	74.03	0.00	0.00	80.97	0.00	0.00	
Corn Starch	0.00	61.69	0.00	0.00	68.08	0.00	0.00	74.46	0.00	
Glucose	0.00	0.00	58.61	0.00	0.00	64.67	0.00	0.00	70.74	
V/M premix	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	
Total	**100.01**	**100.00**	**100.00**	**100.00**	**100.01**	**100.00**	**100.00**	**100.16**	**100.00**	
Proximate values	Diet1	Diet2	Diet3	Diet4	Diet5	Diet6	Diet7	Diet8	Diet9	Diet10
Crude protein	29.61	29.86	29.96	24.75	24.69	24.98	19.98	20.69	19.45	44.65
Crude fibre	4.00	7.00	7.00	3.92	7.00	3.00	3.00	5.88	6.93	15.84
C.Fat	10.94	8.78	4.38	5.94	5.88	5.41	5.41	5.97	5.00	12.92
Ash	40.20	41.10	44.00	40.78	40.35	42.87	41.87	32.46	35.95	5.34
NFE	5.45	3.16	5.77	14.83	12.10	13.98	20.98	25.50	24.00	11.15
Moisture	9.80	10.10	8.89	9.78	9.98	9.76	8.76	9.50	8.67	10.10
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100.04**	**100**

Table 2: Mean growth parameters of *Clarias gariepinus* fed various Carbohydrates: Protein ratios for 8 weeks

Parameters	5CF:30 P	10CF: 25P	20CF: 20P	5CS: 30P	10CS: 25P	20CS: 20P	5GL: 30P	10GL: 25P	20GL: 20P	CRD	SD ±
Initial Body Wt (g)	1.72^{a}	1.80^{a}	1.87^{a}	1.72^{a}	1.72^{a}	1.72^{a}	1.68^{a}	1.83^{a}	1.53^{a}	1.68^{a}	0.18
Final Body Wt. (g)	3.17^{b} ±1.75	2.02^{c} ±0.11	2.14^{c} ±0.37	2.25^{c} ±0.52	2.61^{b} ±0.56	2.04^{c} ±0.16	1.89^{c} ±0.29	2.00^{c} ±0.09	1.83^{c} ±0.35	6.55^{a} ±1.34	0.76
Weight gain (g)	1.46^{b} ±1.74	0.37^{bc} ±0.31	0.27^{bc} ±0.10	0.54^{c} ±0.51	0.90^{c} ±0.58	0.32^{bc} ±0.31	0.21^{bc} ±0.31	0.18^{bc} ±0.05	0.30^{bc} ±0.39	4.87^{a} ±1.18	0.74
SGR(%)	1.09^{b} ±0.90	0.21^{cd} ±0.48	0.24^{cd} ±0.08	0.48^{d} ±0.40	0.75^{c} ±0.40	0.31^{cd} ±0.33	0.21^{cd} ±0.14	0.16^{cd} ±0.04	0.32^{cd} ±0.38	2.42^{a} ±0.21	0.41
FCR	3.06^{c} ±2.32	3.29^{c} ±1.89	3.24^{c} ±2.55	4.02^{b} ±3.22	2.67^{c} ±1.26	4.45^{a} ±1.70	4.32^{b} ±0.00	4.95^{a} ±0.00	2.59^{c} ±0.00	0.41^{d} ±0.09	1.99
PER	2.86^{b} ±3.40	0.91^{d} ±0.76	0.73^{d} ±0.28	0.92^{d} ±0.88	1.87^{c} ±1.21	2.94^{b} ±2.74	0.36^{e} ±0.39	0.38^{e} ±0.10	0.81^{d} ±1.04	5.19^{a} ±1.25	1.57
ANPU(%)	43.43^{f} ±0.01	75.91^{c} ±0.01	91.49^{b} ±0.01	1.60^{j} ±0.01	66.26^{d} ±0.01	59.19^{e} ±0.01	13.03^{i} ±0.01	38.51^{g} ±0.01	95.53^{a} ±0.01	30.88^{fg} ±0.01	0.01
Survival (%)	53.34^{d} ±23.09	60.00^{c} ±6.67	62.22^{c} ±7.70	68.89^{b} ±36.71	46.67^{bc} ±24.04	71.11^{b} ±10.18	40.00^{e} ±0.00	44.44^{bc} ±15.39	40.00^{e} ±24.04	75.55^{a} ±16.78	19.40

Mean data on the same row carrying letters with different superscripts are significantly different ($p<0.05$) from each other

Table 3: Body composition of *Clarias gariepinus* fed different carbohydrate sources to different Protein ratio.

Proximate analysis	Initial	CORNFIBRE			CORNSTARCH			GLUCOSE-D			CRD	SD ±
		C5:P30	C10:P25	C20:P20	C5:P30	C10:P25	C20:P20	C5:P30	C10:P25	C20:P20		
Crude protein	52.95^{dc} ±0.01	63.55^{c} ±0.00	66.78^{b} ±0.01	66.33^{b} ±0.01	53.37^{dc} ±0.01	67.15^{b} ±0.01	63.47^{c} ±0.01	55.34^{c} ±1.72	61.04^{d} ±0.01	68.99^{a} ±0.01	66.06^{b} ±0.01	0.52
Crude fat	5.39^{bc} ±0.01	9.52^{a} ±0.01	3.78^{c} ±0.02	4.45^{cd} ±0.01	5.72^{d} ±0.01	5.26^{cd} ±0.01	2.98^{b} ±0.01	2.70^{b} ±0.01	7.04^{ac} ±0.01	5.44^{cd} ±0.01	6.17^{d} ±0.01	0.01
Crude fibre	1.23^{e} ±0.01	6.20^{b} ±0.01	7.17^{a} ±0.04	6.12^{b} ±0.01	5.71^{b} ±0.01	7.02^{a} ±0.01	5.97^{b} ±0.02	3.71^{d} ±0.01	3.99^{d} ±0.01	4.65^{c} ±0.01	3.56^{d} ±0.01	0.02
Ash	5.60^{de} ±0.06	10.13^{c} ±0.01	.5.31^{f} ±0.01	3.91^{ef} ±0.01	6.63^{c} ±0.06	4.88^{f} ±0.01	15.95^{b} ±0.01	18.20^{a} ±0.01	7.65^{d} ±0.01	10.93^{c} ±0.06	5.31^{f} ±0.01	0.02
NFE	8.66^{a} ±0.01	0.36^{e} ±0.01	2.01^{c} ±0.01	3.11^{b} ±0.01	1.10^{d} ±0.01	1.99^{c} ±0.01	0.99^{d} ±0.01	0.49^{d} ±0.01	1.00^{d} ±0.01	0.17^{e} ±0.01	1.90^{c} ±0.01	0.01
Moisture	26.15^{b} ±0.01	10.25d^{f} ±0.01	14.91^{e} ±0.01	16.08^{d} ±0.01	27.47^{a} ±0.01	13.68^{e} ±0.01	10.57^{f} ±0.01	18.55^{c} ±0.01	19.25^{c} ±0.01	9.87^{f} ±0.01	16.99^{d} ±0.01	0.01

Mean data on the same row carrying letter(s) with different superscripts are significantly different ($p<0.05$)

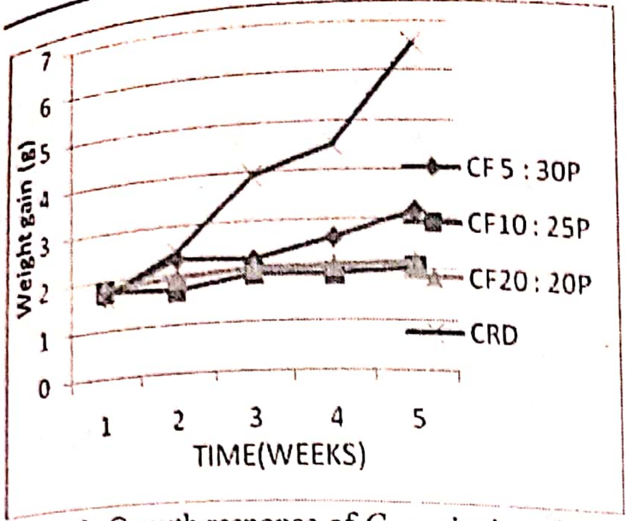

Figure1: Growth response of *C. gariepinus* fed different Cornfibre/Protein ratios

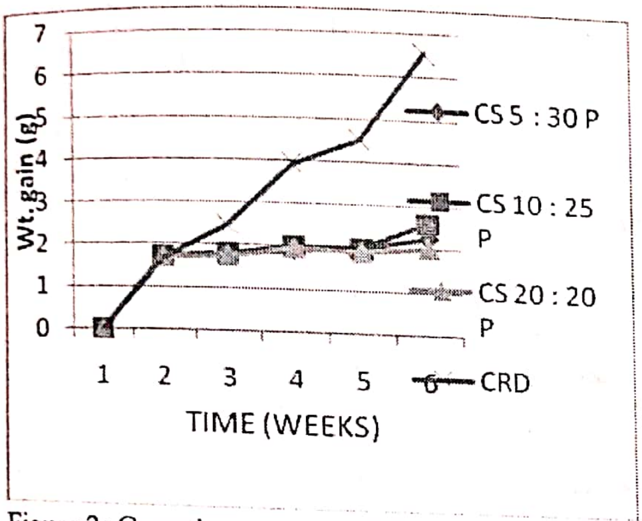

Figure 2: Growth response of *C. gariepinus* fed different Cornstarch/Protein ratios

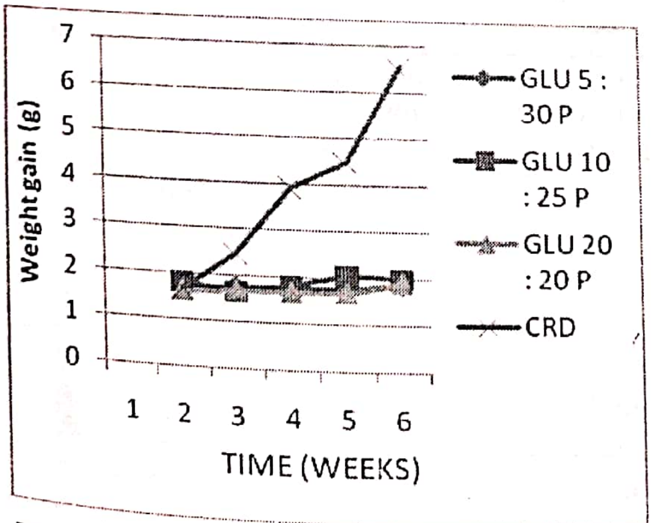

Figure 3: Growth response of *C.gariepinus* fed different Glucose/Protein ratios

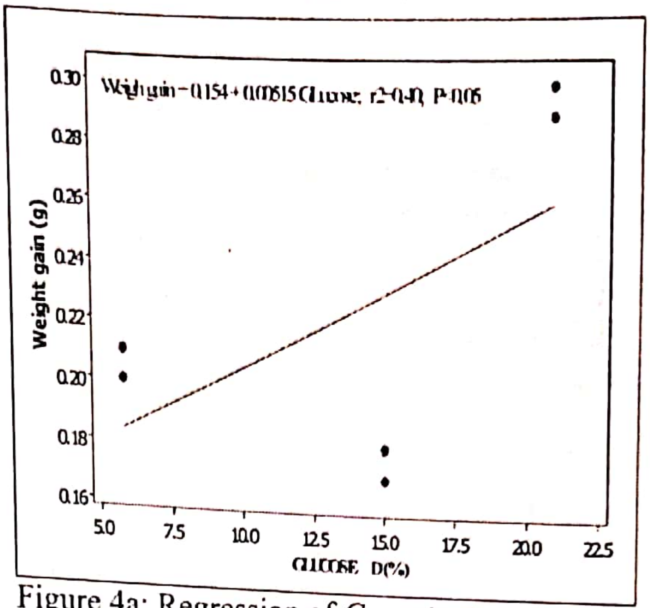

Figure 4a: Regression of *C. gariepinus* fed with different levels of Glucose/ Protein based diets

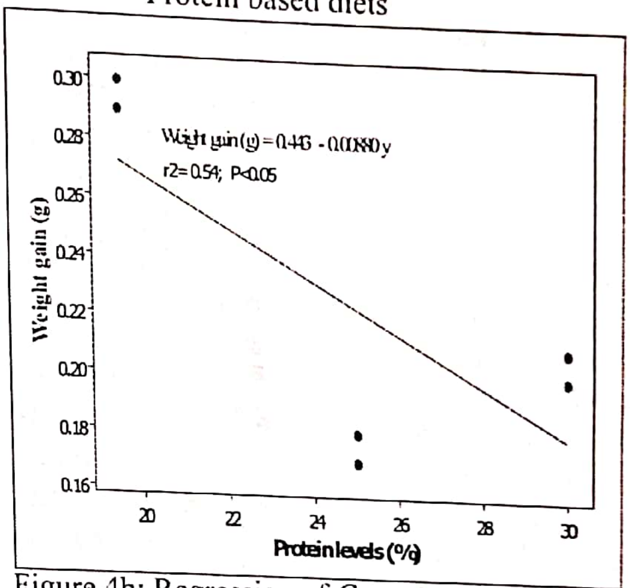

Figure 4b: Regression of *C. gariepinus* fed with different levels of Glucose/ Protein based diets

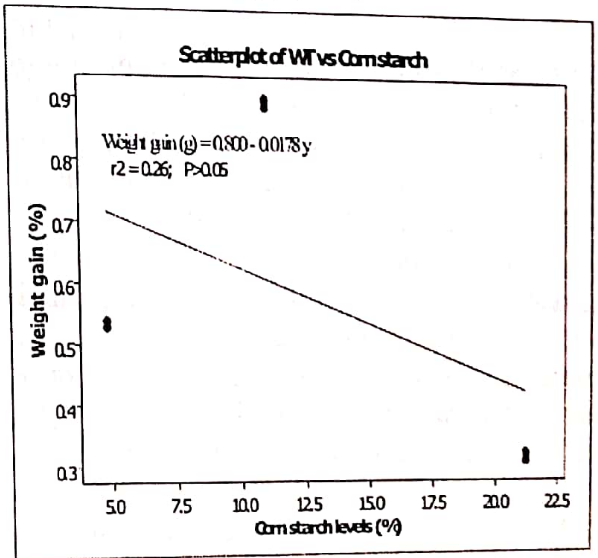

Figure 5a: Regression of *C. gariepinus* fed with different levels of Corn starch/ Protein based diets

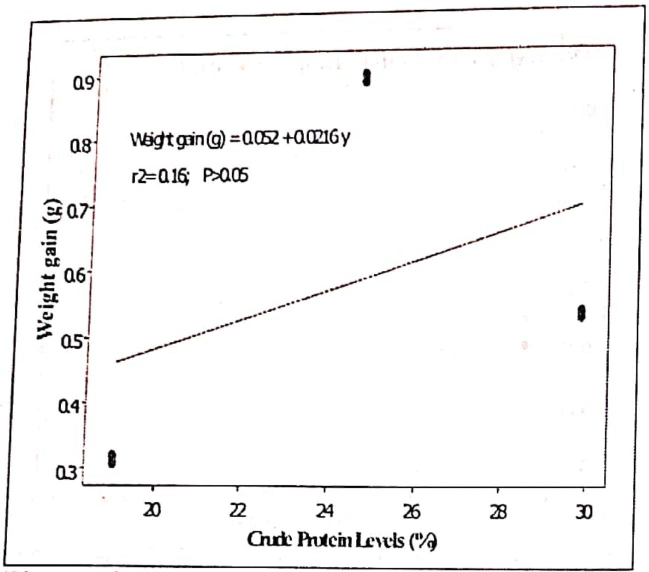

Figure 5b: Regression of *C. gariepinus* fed with different levels of Corn starch/ Protein based diets

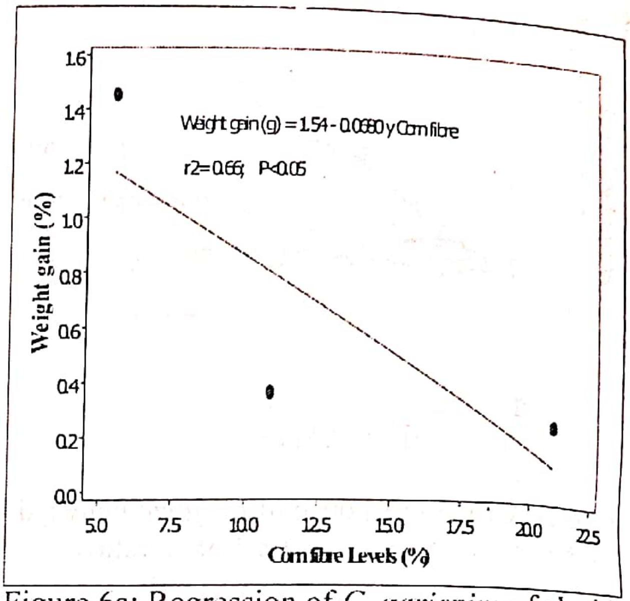

Figure 6a: Regression of *C. gariepinus* fed with different levels of Cornfibre/Protein based diets

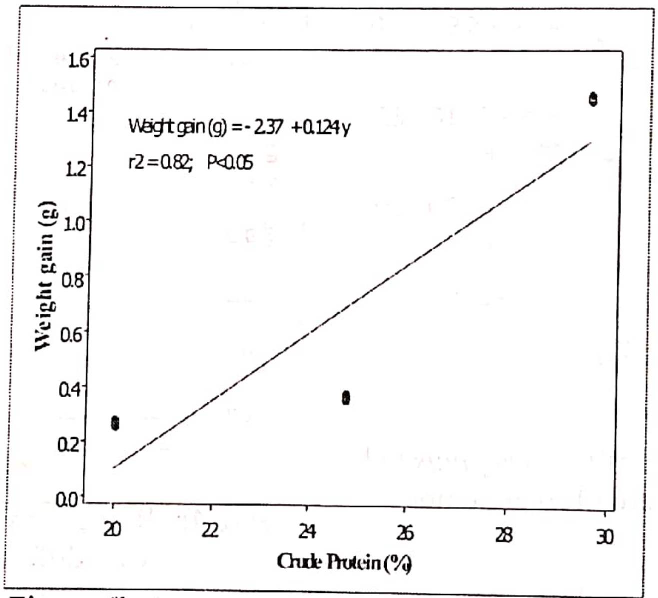

Figure 6b: Regression of *C. gariepinus* fed with different levels of Corn fibre/ Protein based diets